TITLE OF THE INVENTION:

Method and Apparatus for maintaining filaments in position in a filament winding process

FIELD OF THE INVENTION

The present invention relates to a method of maintaining filaments in position when manufacturing composite parts through a filament winding process and an apparatus constructed to implement the teachings of the method.

BACKGROUND OF THE INVENTION

Published Canadian Patent Application 2,274,328 (Elliott 1999) describes a problem being encountered in filament winding processes of resin coated filament fibres sliding off the mould during filament winding. The solution proposed by Elliott was to wind dry filament onto the surface of the mould and then subsequently infuse resin into the dry filament. This dry filament winding has met with limited success, but is not always suitable.

SUMMARY OF THE INVENTION

What is required is a method and apparatus for maintaining filaments in position when manufacturing composite parts through a filament winding process.

According one aspect of the present invention there is provided a method for maintaining filaments in position when manufacturing composite parts through a filament winding process. In its most basic form the method includes a first step of applying resin impregnated filament onto an elongate mandrel. A second step is involved of winding yarn onto the elongate mandrel overlying the resin impregnated filament, to maintain the resin impregnated filament in position and under tension.

Once the basic method is understood, there are various ways to further refine the process, as will be apparent from

the full description of the method which follows.

According another aspect of the present invention there is provided an apparatus for maintaining filaments in position when manufacturing composite parts through a filament winding process. In its most basic form the apparatus includes a mandrel together with means for selectively rotating the mandrel. A ring is provided which is co-axial to and encircles the mandrel. A spool of yarn or multiple spools is mounted on the ring. Means are provided for causing the spool to orbit the mandrel and thereby apply yarn circumferentially to the mandrel.

Once the basic apparatus is understood, there are additional features, which may be added, as will be apparent from the full description of the apparatus, which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description in which reference is made to the appended drawings, the drawings are for the purpose of illustration only and are not intended to in any way limit the scope of the invention to the particular embodiment or embodiments shown, wherein:

FIGURE 1 is a perspective view of an apparatus for maintaining filaments in position in a filament winding process, shown in use for unidirectional winding in accordance with the teachings of the preferred method.

FIGURE 2 is a perspective view of the apparatus illustrated in **FIGURE 1**, shown at the end of a pass of unidirectional winding.

FIGURE 3 is a perspective view of the apparatus illustrated in **FIGURE 1**, shown in use for angular winding.

FIGURE 4 is a side elevation view of the apparatus illustrated in **FIGURE 3**, shown at the end of a forward pass of angular winding.

FIGURE 5 is a side elevation view of the apparatus illustrated in **FIGURE 3**, shown at the end of a return pass of angular winding.

FIGURE 6 is a detailed side elevation view of the apparatus illustrated in **FIGURE 1**, shown in use with unidirectional winding.

FIGURE 7 is a detailed side elevation view of the apparatus illustrated in **FIGURE 1**, shown in transition deviating from unidirectional.

FIGURE 8 is a detailed side elevation view of the apparatus illustrated in **FIGURE 1**, shown in use with angular winding.

Figure 9 is an end elevation of the apparatus shown in use for unidirectional winding

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred apparatus, generally identified by reference numeral 10 and the preferred method, will now be described with reference to **FIGURES 1** through **9**.

Structure:

There will first be described apparatus 10 which was developed for maintaining filaments in position when manufacturing composite parts through a filament winding process. Apparatus 10 includes an elongate mandrel 12. At least one impregnation box 14 is provided. In the illustrated embodiments two have been shown. Each impregnation box is adapted to wet filament 16 with resin 18 prior to application of filament 16 onto mandrel 12. Guide rollers 20 are provided to control application of filament 16 onto mandrel 12. Means are provided for selectively rotating mandrel 12. As the means are well known in the art, they have not been illustrated, but are indicated by arrow 22. As will hereinafter be described in relation to the method, by selectively rotating mandrel 12 the orientation of filaments 12 can be altered. Collars 24 are provided with projecting spikes 26, which provide spacing and anchoring points for the

roving particularly when it is orientated on or close to the axis. On larger mandrels the spiked collars can be substituted by grooves in the mandrel, which perform the same function.

Collars 24 are positioned in spaced relation on mandrel 12. Collars 24 are adapted to assist in maintaining filament positioning and spacing by segregating filaments 12 with projecting spikes 26. A ring 28 is provided which is co-axial to and encircles mandrel 12. A spool 30 containing yarn 32 is mounted on ring 28. Means are provided for rotating ring 28 about its axis. As one skilled in the art would be aware of suitable means for rotating ring 28, it has not been illustrated. The rotation of ring 28 is indicated by arrow 34. The rotation of ring 28 causes spool 30 to orbit mandrel 12, thereby applying yarn 32 circumferentially to mandrel 12 overlying filament 16 to maintain filament 16 in position, as will hereinafter be further described.

Method:

Filament roving or tape is pulled through an impregnation box, which opens out the filaments and aligns and controls the roving spacing (figure 1). The aligned roving then proceeds through a resin bath and out via a series of rollers. The effect of the guide rollers is to facilitate wet out by forcing resin in to the filaments of the opened rovings.

Subsequent rollers maintain tension and squeeze off the excess resin on the glass fibre. The result is an opened aligned tensioned roving, which has had the filaments, wetted by the resin and the excess resin removed. By setting the guide configurations and the roller angles the path of the roving can be altered. This enables control and adjustment of the roving for alignment, spacing, tension and degree of impregnation with regards to the resin.

There are a number of ways in which the impregnation box can be used to impregnate filament roving with resin. One way is to inject the resin such as polyurethane directly into the roving at the entry of the impregnation box and allows the rollers to work in and squeeze off the excess resin.

In this instance resin in the resin tray is as a direct result of excess being squeezed from the roving. In another method the resin tray is filled with a liquid resin such as polyester epoxy or vinylester and the resin allowed to impregnate the fibrous roving by the action of immersion together with the effects of the rollers, which serve to wet out and squeeze off any excess. In this way short pot life resins can be used via resin injection and longer pot life resins can be employed using a more conventional resin bath immersion technique.

A third embodiment is to use pre-impregnated roving or tape, which consists of resin and a fibrous reinforcement such as Twintex which is a co-mingled glass and polypropylene material. In this instance the glass, resin and fibrous reinforcement (roving) would simply bypass the impregnation stage, as the resin is already part of the roving. The roving or tape would then proceed through the guide rollers in the same way as wet winding, however, in this instance the material would be dry.

Each impregnation box (14) is mounted on the roving carriage (36) and is responsible for delivering a series of individual filament rovings via the guide rollers (20) that have been spaced, tensioned and wet out and is referred to as a head (figure 9). The device is constructed so that multiple heads operate together delivering a series of filament roving on to the mandrel two are shown in figure 9.

The cycle typically begins with an initial circumferential

wrap of the roving on the mandrel, which is located outside the winding area. This acts as an anchor point in order that the filament roving can generate tension during winding.

In one embodiment the head delivering the filament roving now traverses down the mandrel and the roving path progresses over a spiked collar. This collar maintains the position of the roving on the mandrel. In another embodiment the carriage (36) is stationery and the mandrel is moved back and forth

At the end of the pass another circumferential wrap of the roving is undertaken again to act as an anchor point in order that the roving is held in position and tension Figure 2. During the process of unidirectional winding a yarn made from materials such as monofilament polymer, glass, carbon or aramid is wrapped over the filaments (Figure 1 and 6). The yarn spool is attached to a ring that can travel the length of the mandrel and rotate (Figure 1 and 2). The number of wraps together with the angle of wrap can be predetermined as to provide the maximum stability to the filament winding by programming the rate of travel and rate of rotation of the ring which in turn houses the yarn spool.

In order to produce circumferential winding the head transverses down the length of the mandrel whilst the mandrel is rotated. By adjusting the speed of the travel to the speed of rotation roving can be wrapped on at angles ranging from 90°-0°. Circumferential windings are usually quite stable and do not require over wraps, so shown in Figure 3, 4, 5 and 8. Figure 6 denotes the axis reference.

When placing axial fibres on a mandrel a yarn or single filament is delivered from one or more than one spools used to hold them in place from slipping (Figure 1 and 2). This is done by having two rotating rings (one on each side of the heads as shown in figure 1) with spools of fibre (for

example: glass roving, Kevlar, acrylic yarn, nylon mono filament, etc) and movable arms with ceramic eyelets (33). These are attached on each side of the fibre placement head, enabling the machine to use the trailing ring to apply a strand of fibre around the mandrel to pull the axial fibres onto the mandrel. The amount of tension can be adjusted to suit by adjusting the tension on the spool.

One or more heads are used to apply the fibres (Figures 1, 2,3 and 9 show a two head configuration). The fibre placement heads have PLC control to allow them precise positioning of the guide rollers (20) as they move along the mandrel. This control of the head position allows them to increase or decrease the band width of the filament rovings when applying axial fibre by adjusting the distance the head is from the mandrel. Guide rollers (20) can pivot to any angle between vertical and horizontal which also can be used to control the spacing between individual fibre strands by rotating the head as it deploys axial fibre. Figure 1 and 2 show the vertical position and figure 3 shows the horizontal position.

The device has complete control over all axis's. The mandrel can be rotated in ether direction or stopped at a predefined position to lay down fibre. Layers can be applied with all the fibre being in one direction (Figure 4 and 5) by rotating the mandrel in the opposite direction to the last pass to fill in the gaps until complete a layer is applied. Geodesic winding can also be wound.

In this patent document, the word "comprising" is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article "a" does not exclude the possibility that more than one of the element is present, unless the context clearly requires that there be one and only one of the elements.

It will be apparent to one skilled in the art that modifications may be made to the illustrated embodiment without departing from the spirit and scope of the invention as hereinafter defined in the Claims.